claims 12-14 and 18-19 are anticipated by Reference No. 8 in Figure 3 of Ohnishi, et al. In response, Applicants pointed out that a **metal** is not the same as a metal oxide. Chemically and electrically a metal is quite distinct from and acts differently from a metal oxide. A metal forms positive ions when its compounds are in solution. A metal oxide forms hydroxides rather than acids with water. This is a fundamental difference. As such, it is impossible for a recitation of a metal layer element to encompass a metal oxide film layer element. Ohnishi, et al. teaches only that it is known to use metal oxide heater film layers. A metal oxide heater layer element is clearly **not a metal** heater layer element.

In the Advisory Action mailed January 26, 2005, the Examiner states:

> However true that may be, the fact that the claims are not clear in specifying or distinguishing a metal from a metal oxide layer makes it possible to reject the recited "metal" layer with the "metal oxide" layer of Ohnishi. While Applicant admittedly makes no attempt to show that a metal heater is not inclusive of a metal oxide film heater, it is held that the broad interpretive reading of the Ohnishi reference to read on the invention as claimed is proper. As a result, Applicant's arguments do not place the application in condition for allowance at this time.

Accordingly, enclosed with this Supplemental Response are three references from the Internet that show that the material referred to commercially as ITO or indium tin oxide is 91 mol% indium oxide (In_2O_3), with 9 mol% tin oxide (SnO_2), also referred to as tin (IV) oxide, or 90 wt% indium oxide with 10 wt% tin oxide. One reference refers to this as "tin-doped indium oxide."

Metals are not transparent, although metal oxides can be. Please refer to *Principles of Materials Science and Engineering*, 3rd edition, by William F. Smith, page 837, a copy of which is also attached. Referring to "metals," Professor Smith states that "except for very thin sections, metals strongly reflect and/or absorb incident radiation" and that "this type of action results in strongly reflected beams of light from a smooth surface." Thus, Applicants urge the Examiner to reconsider his rejection, based on the plain meaning of the term "metal" to one of ordinary skill and its distinction from "metal oxide."

The Examiner is respectfully requested to reconsider his position. Ohnishi, et al. cannot anticipate Applicants' independent claim 12. For this reason the rejection is improper and should be withdrawn. Claim 12 is clearly allowable over the cited prior art. As claims 13-14 and 18-19 depend from claim 12 these claims are also clearly allowable and such action is earnestly solicited.

Claim Rejections under 35 U.S.C. § 103

Claims 2, 4-9, and 16-17 stand rejected as unpatentable over Ohnishi, et al. in view of Taniguchi, et al. and further in view of Shin, et al. Neither one of these references disclose metal heater layers as claimed in Applicants' independent claim 12. Since these claims depend from claim 12 and claim 12 requires a metal heater layer, this combination of references cannot render Applicants' claims 2, 4-9, 16-17 obvious. Therefore this rejection should also be withdrawn.

Claim 10 stands rejected as unpatentable over Ohnishi, et al. in view of the references set forth above and Muhlemann. Again, a review of Muhlemann reveals that this reference also does not disclose or teach a metal heater layer as claimed in independent claim 12. Accordingly, this rejection must fall along with the other rejection above. This rejection should be withdrawn.

Claim 20 stands rejected as unpatentable over Ohnishi, et al. in view of Muhlemann. Again, a review of Muhlemann reveals that this reference also does not disclose or teach a metal heater layer as claimed in independent claim 12. Accordingly, this rejection must fall along with the other rejection above. This rejection should be withdrawn.

Claims 2, 4-10, 12-14 and 16-20 are pending in the application. These claims are believed to be allowable.

Double Patenting

The conflict with co-pending application 10/769,843 is believed to have been resolved. An appropriate amendment was filed in that case on January 17, 2006, which renders this double patenting rejection moot in this case. It is respectfully submitted that all of the Examiner's

rejections have been successfully traversed and that the application is now in order for allowance. Accordingly, reconsideration of the application and a favorable indication of allowable subject matter is courteously solicited.

The Director is authorized to charge **$450.00** in fees for a petition for a two month extension for the period to respond, as well as any additional fee(s) or any underpayment of fee(s), or to credit any overpayments to **Deposit Account Number 50-2638**. Please ensure that Attorney Docket Number 73538.020500 is referred to when charging any payments or credits for this case.

Respectfully submitted,

Date: February 6, 2006

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LA-FS1\386897v01

THIRD EDITION

PRINCIPLES OF MATERIALS SCIENCE AND ENGINEERING

William F. Smith
Professor of Engineering
University of Central Florida

McGraw-Hill, Inc.
New York St. Louis San Francisco Auckland Bogotá
Caracas Lisbon London Madrid
Mexico City Milan Montreal New Delhi
San Juan Singapore Sydney Tokyo Toronto

(14.3)

ı one with a
if increased
ϕ_c angle ıs

a flat plate of

glass

eflection

$$\sin \phi_c = \frac{1}{1.51} (\sin 90°) = 0.662$$

$$\phi_c = 41.5° ◀$$

Note: We shall see in Sec. 14.7 on Optical Fibers that by using a cladding of a low-refractive-index glass surrounding a core of high refractive index, an optical fiber can transmit light for long distances because the light is continually reflected internally.

14.4 ABSORPTION, TRANSMISSION, AND REFLECTION OF LIGHT

Every material absorbs light to some degree because of the interaction of light photons with the electronic and bonding structure of the atoms, ions, or molecules which make up the material. The fraction of light transmitted by a particular material thus depends on the amount of light reflected and absorbed by the material. For a particular wavelength λ, the sum of the fractions of the incoming incident light reflected, absorbed, and transmitted is equal to 1:

$$(\text{Reflected fraction})_\lambda + (\text{absorbed fraction})_\lambda + (\text{transmitted fraction})_\lambda = 1 \quad (14.4)$$

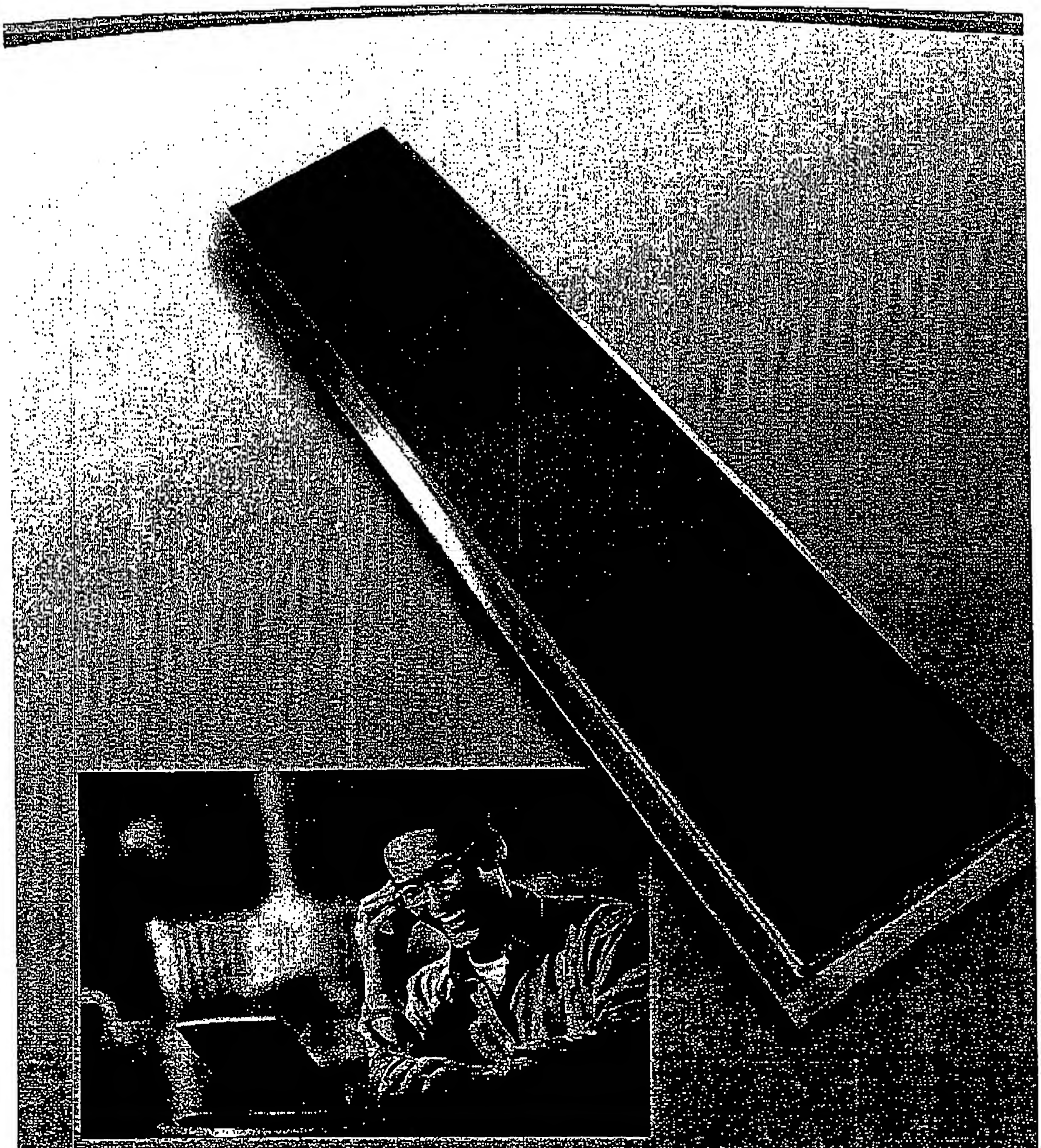
Let us now consider how these fractions vary for some selected types of materials.

Metals Except for very thin sections, metals strongly reflect and/or absorb incident radiation for long wavelengths (radio waves) to the middle of the ultraviolet range. Since in metals the conduction band overlaps the valence band, incident radiation easily elevates electrons to higher energy levels. Upon dropping to lower energy levels, the photon energies are low and their wavelengths long. This type of action results in strongly reflected beams of light from a smooth surface, as is observed for many metals such as gold and silver. The amount of energy absorbed by metals depends on the electronic structure of each particular metal. For example, with copper and gold there is a greater absorption of the shorter wavelengths of blue and green and a greater reflection of the yellow, orange, and red wavelengths, and thus smooth surfaces of these metals show the reflected colors. Other metals such as silver and aluminum strongly reflect all parts of the visible spectrum and show a white "silvery" color.

Silicate Glasses **Reflection of light from a single surface of a glass plate** The proportion of incident light reflected by a single surface of a polished glass plate is very small. This amount depends mainly on the refractive index of the glass n and

Indium Tin Oxide (ITO) Sputtering Target

umicore



Indium tin-oxide

From Wikipedia, the free encyclopedia

Physical Properties	
State of matter	Solid
Melting point	1800-2200 K (2800-3500 °F)
Density	7120-7160 kg/m^3 at 293 K
Color (in powder form)	Pale yellow to greenish yellow, depending on SnO_2 concentration
Values vary with composition.	
SI units & STP are used except where noted.	

Indium tin oxide (**ITO**) is a mixture of indium (III) oxide (In_2O_3) and tin(IV) oxide (SnO_2), typically 90% In_2O_3, 10% SnO_2 by weight. ITO is mainly used to make transparent conductive coatings for flat panel displays, and infrared-reflecting coatings for architectural, automotive, and sodium vapor lamp glasses.

Uses

Typical applications of ITO-coated substrates include:

- **Electrodes for LCD and electrochromic display devices.**
- Touch fg panel contacts.
- Energy conserving architectural windows.
- **Defogging aircraft and automobile windows.**
- Heat-reflecting coatings to increase light bulb efficiency.
- Gas sensors.
- Antistatic window coatings.
- Wear resistant layers on glass.
- Heat deflecting windows for slide projection and optics work

As of November 2004, sales of flat panel displays, televisions and monitors which require ITO have driven the price of indium to $900/kg, its highest level since 1939, according to Reuters (http://www.reuters.com/newsArticle.jhtml?type=technologyNews&storyID=6930378).

BV868946/9/2005/1000

Indium Tin Oxide (ITO) high density sputtering target

Principal Uses

Sputtering of ITO for use in displays, touch screens, OLED, LED, solar cells and other thin film applications.

Physical data

Umicore ceramic ITO sputtering targets are manufactured by pressureless sintering.

Microstructure	Single phase
Max. theoretical density	7.14 g/cm³
Ultra high density grade	≥ 99%
Flexural strength	150 MPa
Electrical resistivity	< 170 µΩcm
Thermal conductivity	0.1 W/cm.K
Appearance	Dark green/black

Analysis

In_2O_3/SnO_2 in a 90/10 wt% ratio (consistent to within ± 0.6 wt%). Other ratios are available on request. The typical overall purity is 4N; i.e. the total of all elements listed below does not exceed 100 ppm.

Sb		Bi	
Pb		Al	
Cu		K	
Zn		Mg	
Fe		Na	
Ni		Ti	
Cr			

Target dimensions and bonding

Bonding on Cu, Mo or Ti backing plates is with pure Indium. A certificate of compliance for bonding accompanies each shipment.

Rectangular	
Max. length/tile	different dimensions available upon request
Max. width/tile	different dimensions available upon request
Max. thickness	different dimensions available upon request
Tile gap	0.015" ± 0.003" (0.3 ± 0.1 mm)
Tolerances for length, width, thickness	± 0.005" (± 0.13 mm)

Larger targets can be assembled from multiple tiles.

Discs	
Max. diameter	8" ± 0.010" (203 ± 0.25 mm)
Max. thickness	0.394" ± 0.005" (10 ± 0.13 mm)

Available Formats and Packing

Packaging is available to customer's requirements. To reduce environmental impact, custom re-usable shipping containers can be made upon request.

Handling and Safety

Material safety data sheet (MSDS), sent with first shipment and available upon request.

General remarks

- Umicore advises its customers to verify the relevant intellectual property that is related to the use of these products.
- Product specifications as indicated in this brochure can be changed without prior notice. Umicore welcomes more detailed customer specifications.
- Umicore offers recycling programs for its materials.

Please find your local sales partner at:
www.thinfilmproducts.umicore.com

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TECHNICAL PUBLICATIONS

ITO, TIN-DOPED INDIUM OXIDE FOR OPTICAL COATING

Introduction

Indium oxide doped with tin oxide, ITO, is used to make transparent conductive coatings. Thin film layers can be deposited by electron-beam evaporation or sputtering. Roll or web coating on polymer substrates is done by magnetron or other techniques of sputtering.

Typical applications of ITO-coated substrates include touch panel contacts, electrodes for LCD and electrochromic displays, energy conserving architectural windows, defogging aircraft and automobile windows, heat-reflecting coatings to increase light bulb efficiency, gas sensors, antistatic window coatings, wear resistant layers on glass, etc.

Contents:

Film Properties
Refractive Index
Material Behavior
Electron-Beam Deposition Parameters
Physical Properties of Solid ITO Material
Sputter Deposition
Sputtered Film Applications
Forms and Sizes Available from CERAC

Film Properties

The optical and electronic properties of ITO films are highly dependent on the deposition parameters and the starting composition of evaporation material used. The deposited film layer must contain a high density of charge carriers for it to conduct. These carriers are free electron and oxygen vacancies, and an excessive population produces absorption. High conductivity (or low sheet resistance) is balanced against high transmission in the visible region. Sheet resistance can be less than 10 Ohms/sq. with a visible transmission of >80%. To obtain transmission near 90%, sheet resistance must be >100 Ohms/sq. ITO films behave as metals to long wavelength light because of the presence of a plasma wavelength above 1 µm. At longer wavelengths, the film becomes reflecting, and the IR reflectance is related to the sheet resistance of the film; sheet resistance must be <30 Ohms/sq. to obtain IR reflectance >80%.

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Refractive Index

The refractive index for a film that is transparent in the visible region remains near 1.95 and is not strongly dependent on the deposition parameters. Index is generally of secondary concern for conducting applications. The extinction coefficient will vary with conductance.

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Material Behavior

The deposition parameters play interdependent roles in the optimization of film properties. Principal among the deposition parameters are partial pressure of oxygen, substrate temperature, rate of deposition and material composition. Some processes require post deposition baking at 300-500° C in air to oxidize residual fractionated metal component and improve conductivity. For sputter processes, a high energy plasma can be substituted for a high substrate temperature.

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Electron-Beam Deposition Parameters

Best results are obtained using reactive evaporation at a slow rate and relatively high pressure because the starting material is reduced (loses oxygen) during evaporation. Recommended preconditioning consists of slowly sweeping a low power electron beam to gradually and uniformly fuse the surfaces of the material and avoid hole drilling by the beam. Monitor the pressure and crucible to minimize outgassing and spitting while slowly increasing the power to just below evaporation temperature.

Evaporation Temperature	~600 ° C
Oxygen Partial Pressure	Near 5 x 10^{-5} Torr. Range
Rate	~2 Å/sec.
Substrate Temperature	Near 300° C.

Film thicknesses should be in the range 1000-2000 Å for high IR reflectivity, but there is little dependence of conductivity on thickness.

The specific geometry of the evaporation system can influence the results, so the parameters listed should be considered guidelines. Post baking in air might be required to adjust the transmission or to obtain minimum sheet resistance.

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Physical Properties of Solid ITO Material

Molecular Weight	Varies with composition
Melting Point	~1900° C
Color	Light yellow to gray, depending on degree of oxidation
Crystal Density	~7.14 g/cc

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Sputter Deposition

CERAC's high density, high-oxide content targets afford good control of film stoichiometry and eliminate the need for post-baking in many cases. DC or reactive RF magnetron techniques are often used for evaporation. Ionized argon is the sputtering gas with a small percentage of oxygen mixed in. The oxidized composition of the CERAC targets requires less oxygen partial pressure than other targets. Sputter deposition parameters include gas composition, flow rate, power density, bias voltage, geometry, plasma current and substrate temperature. Reactive sputtering from high density oxide targets is the most successful method because greater control of film stoichiometry is possible. It is generally necessary to include oxygen to prevent reduction of the evaporant. Example concentrations are 1-3 x 10^{-5} Torr oxygen and 1 x 10^{-2} Torr argon.

Sputtering onto polymer substrates such as PET requires attention to the following parameters. The substrate surface must be free of water and other surface contaminants. Low substrate temperatures for coating polymers are possible with magnetron sputtering. High deposition rates are achieved in roll or web coating systems. Presputtering of the target surface to remove adsorbed

gases and partially reacted layers is essential for success. The addition of a small percentage of hydrogen has been found beneficial in achieving low sheet resistances at low substrate temperature.

Figure 1 gives the dependencies of carrier concentration and resistivity on substrate temperature for a RF sputtered CERAC target. The carrier concentration increased substantially probably due to the creation of more oxygen vacancies at the hotter temperatures. Typically, resistance is traded with transmission, and these are directly related to the degree of oxidation of the film.

Resistivity and Carrier Concentration of Sputtered ITO Films

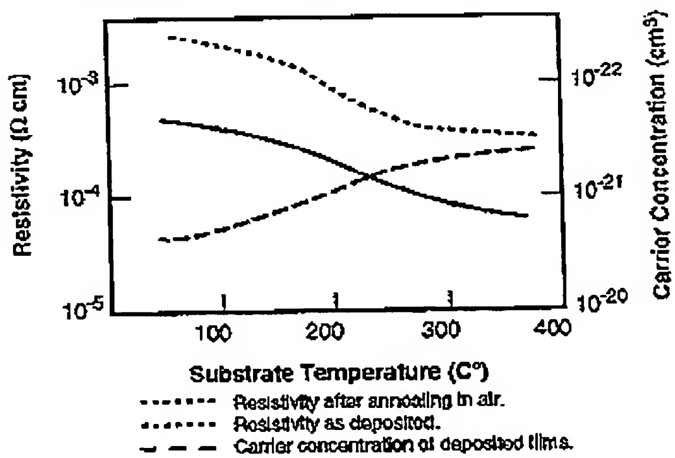

Figure 1 (Adapted from ref. 1.)

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Sputtered Film Applications

The high oxide composition of CERAC's high density target and bulk ITO forms make them ideal for low temperature applications, such as polymer substrates for LCD, touch panels, and other high volume production needs.

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Forms and Sizes Available from CERAC

Item No.	Purity	Description
I-2019	99.99%	$91In_2O_3$-$9SnO_2$ (mol%) 3-12 mm sintered pieces
I-2009	99.99%	$90In_2O_3$-$10SnO_2$(wt%) 3-12 mm sintered pieces

CERAC offers other particle sizes for evaporation as well as sputtering targets of various compositions. To view pricing on the items listed above, please visit our on-line catalog and look-up by item number or chemical name. If you require a custom manufactured item, please contact our sales department at 414-289-

9800 or sales@cerac.com with your specific requirements. You can also fill out our quotation request form.

References

1. Ray Swati, R. Banerjee, N. Basu, A. K. Batabyal, and A. K. Barua, J. Appl. Phys. 54(6), 3497 (1983).

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